Real image – after being bent by the lens the beams from the object converge in one point in space

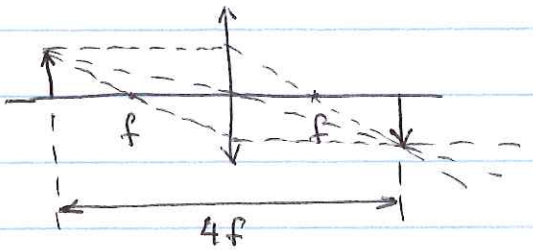
Virtual image – after the lens the beams diverge as if originated from a point behind the lens.

Real image in the image side	$d_i > 0$	Object is inverted $h_i < 0$ $m = h_i/h_o < 0$
Virtual image in the object side (behind the lens)	$d_i < 0$	Object is erect $h_i > 0$ $m = h_i/h_o > 0$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} \qquad d_i = \frac{f \cdot d_o}{d_o - f}$$

Magnification $$m = \frac{h_i}{h_o} = -\frac{d_i}{d_o} = -\frac{f}{d_o - f}$$

For a positive lens $f > 0$, so an object focus is on the object side, and an image focus is on the image side.



$f = 4'' = 20$ cm

$d_o = 8'' = 40$ cm

$$d_i = \frac{20\text{cm} \cdot 40\text{cm}}{20\text{cm}} = 40 \text{ cm}$$

$m = -d_i/d_o = -1$

same size image, but inverted

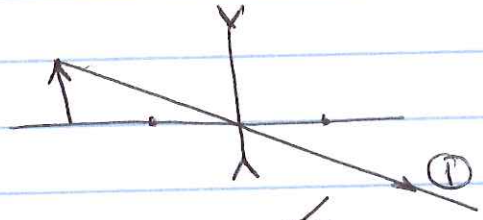
4f imaging system

One uses it to inverse the image, ~~or to collect light from a point~~ without extra distortions

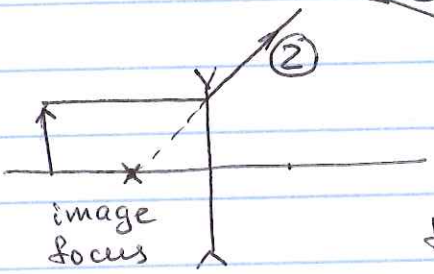
Negative (diverging) lens $f < 0$

Object focus is on the image side, and the image focus is on the object side!

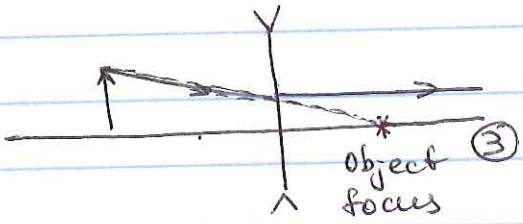
Same three "magic beams", but we have to be careful how to direct them

1. 

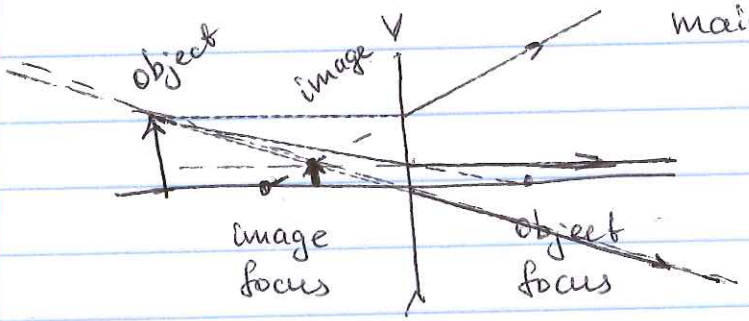
Beam travels through the center of the length with no change

2. 

The beam traveling parallel to the optical axis, after the lens will continue as if it originates from an image focus.

3. 

The beam that aims to the object focus will go parallel to the main axis after the lens



virtual erect image $m < 1$

$f = -20\,cm$

$d_o = 40\,cm$

$$d_i = \frac{d_o \cdot f}{d_o - f} = \frac{(40cm)\cdot(-20cm)}{40cm - (-20cm)} = -\frac{40cm \cdot 20cm}{60cm} \simeq -13cm$$

$d_i < 0$ virtual image

$$m = -\frac{d_i}{d_o} = -\frac{(-13cm)}{40cm} \approx \frac{1}{3}$$

erect reduced image.